# Design of a new full UHV compatible motion system

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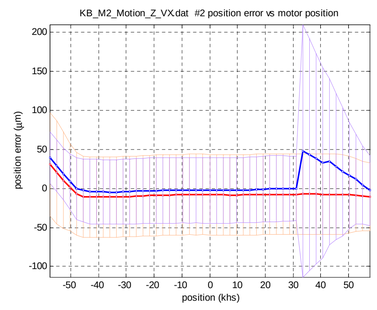
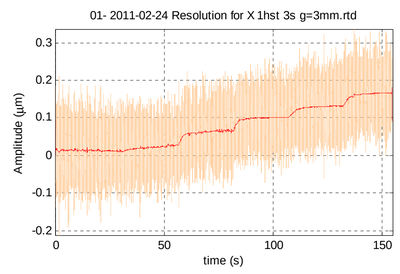
## Abstract

The ALBA synchrotron light facility is a 3GeV storage ring able to work in top up mode which delivers X-Ray beams to seven beamlines, already in operation. During this first beam lines construction phase all the beam lines has been commissioned and placed in operation successfully. Many of beam line mechanical equipment's' started up during this period includes different UHV motion systems which have demonstrated diverse performances related with the type of solution applied to solve the intrinsic vacuum compatibility problems. The equipment's includes many approaches: from air side by means linear and rotation feeds-through, motor and mechanism encapsulations, etc… All these systems have shown some drawbacks: very short duty cycles, high frictions, heating, the added complexity of the necessity of the feed-through, and even in some punctual case the system simply has fail. In order to deal with all this issues a new motion system design is developed full UHV compatible: all items are vacuum compatible avoiding any encapsulation; all moving elements are rolled resulting frictionless system customized with special materials which for the vacuum compatibility which results in turn to maintenance free system. Also the system is designed to support the payload permanently in continuous operation avoiding periodic duty cycles up to in theory infinite life. This for a system which gives 5 mm range for a 250 N maximum payload reaching up a resolution better than 0,1µm. This design has been patented, patent application number U201431338.

## Precedents




*The mirror UHV motion systems in some of the beam lines has failed due:*

- *Not proper design of the motion mechanism which makes a ware out of the spindle thread material*
- *The tribology has not been properly dimensioned*
- *Very short duty cycles*
- *Big backlash*
- *Very low repeatability*
- *Encapsulated: not full UHV compatible*

*During metrology test different malfunctioning were observed:*

- *Stacking*
- *Steps lost*

## Specifications

*UHV motion system which must achieve:*

- *5 mm range (±2,5 mm)*
- *250 N Payload*
- *Irreversible under payload*
- *Long duty cycles (or continuous movement if possible)*
- *Full UHV compatible*
  - *No air encapsulations*
- *0,1 µm resolution*
- *Frictionless mechanics*
- *"miniaturized"*

## Design

*UHV Eccentric wheel:*

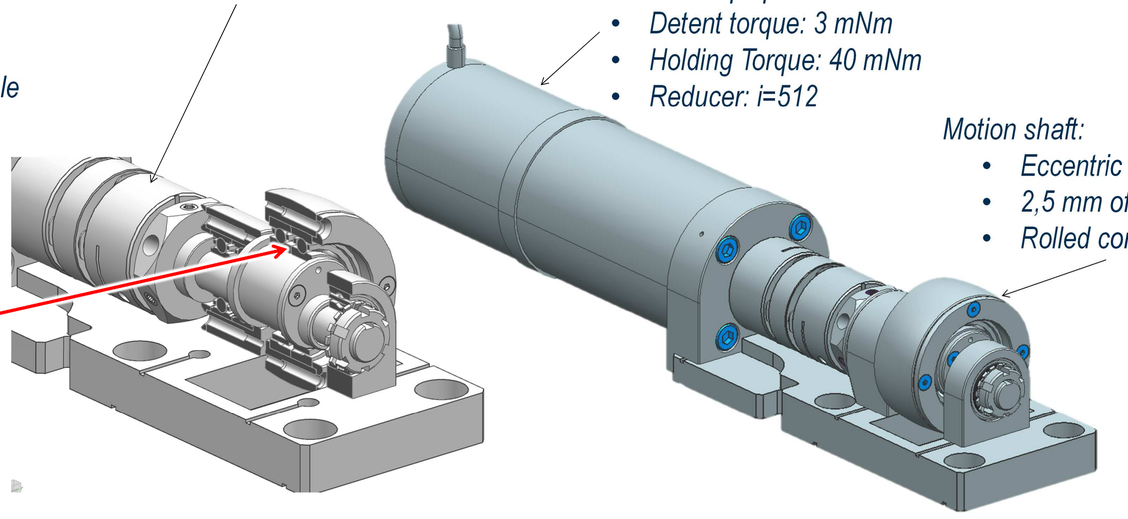
- *Purely rolled cam motion system*
- *There are any dry friction*
- *All components are UHV compatible*
- *No spindle*
  - *This avoids linear guiding*

Hybrid Bearings:

- Stainless steel rings
- Si3N4 balls
- PEEK cages
- Enclosure Material: OPEN
- Dry

*Customized coupling:*

- *All Stainless steel parts*



*UHV compatible stepper motor: Phytron VSS32*

- *Size Ø32 mm*
- *200 steps per turn*
- *Detent torque: 3 mNm*
- *Holding Torque: 40 mNm*
- *Reducer: i=512*

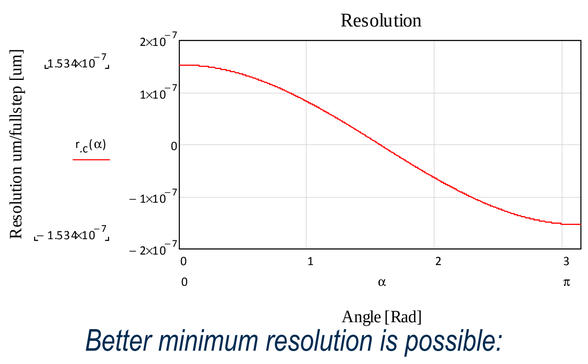
*Motion shaft:*

- *Eccentric Cam wheel (rolled)*
- *2,5 mm off-centred*
- *Rolled contact with moved part*

## Design simulations

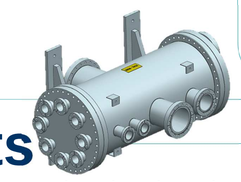
*Resolution:*

- *Variable:*
  - *r(0)= 0,153 µm*
  - *r(π/2)= 4,7·10⁻⁶µm*

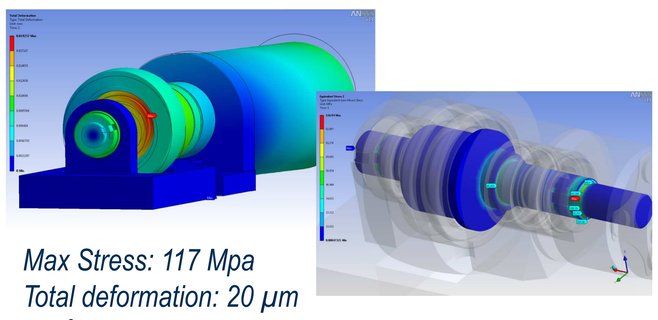



*Better minimum resolution is possible:*

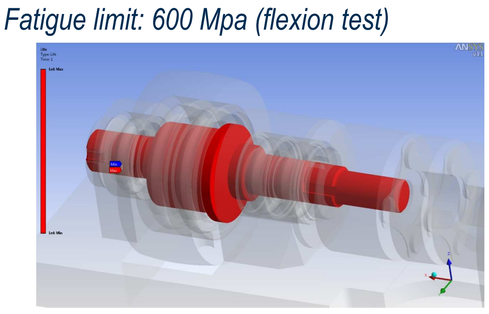
- *Higher ratio reducer are available under customized request*
- *Up to i=1600*
- *R=0,05µm*



*Mechanical simulations*

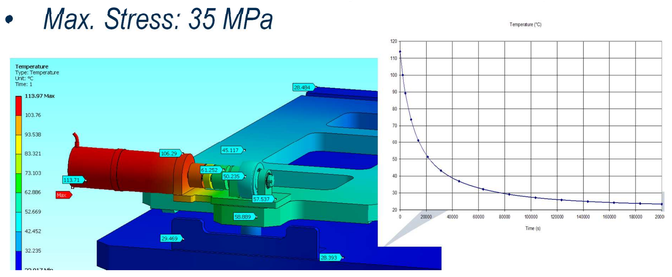


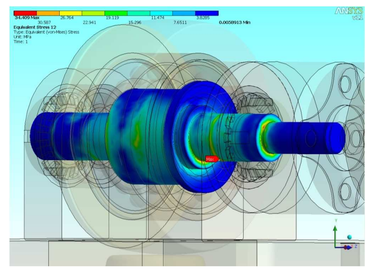
- *Max Stress: 117 Mpa*
- *Total deformation: 20 µm*
- *>10⁶ fatigue cicles*
- *Special material based on AISI-420B alloy*
  - *Fatigue limit: 600 Mpa (flexion test)*



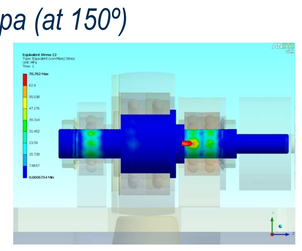
*Thermo mechanical simulations*

- *Continuous motor power at 2,5 W:*
  - *Max Tº=114ºC*
  - *After 28h to reach the steady state at this temp.*
  - *Max. Stress: 35 MPa*





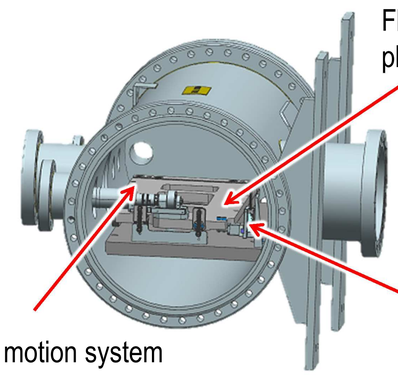
- *Bake out thermomechanical stress:*
  - *71 Mpa (at 150º)*

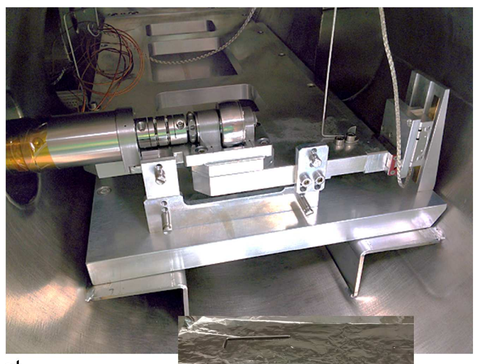


## Construction & tests

*An special vacuum chamber set up for test has been also developed and produced for:*

- *Motions test under vacuum*
- *Continuous works test, temperatures*
- *Bake out test*

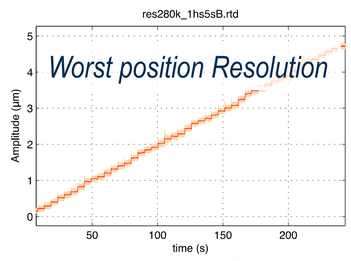


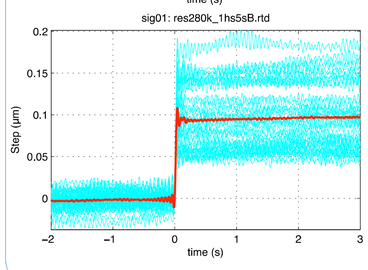



Test reading encoder:

- For UHV motion test
- UHV compatible optical encoder
- 1 nm resolution
- Bakeable 150º

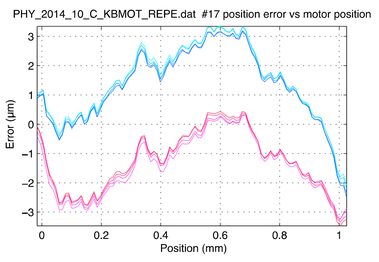
*Preliminar y test*




| | |
|---|---|
| Explored Range | 1.038 mm |
| Avg. resolution | 26.55967699 nm/hs |
| Backlash/Hysteresis | 2.70 um |
| Repeatability | 0.22 um |
| Linearity | 5.56 um |

*Worst position Repeatability*




At atmospheric environment conditions preliminary tests being done:

- Resolution, accuracy, repeatability, backlash, …
- By means laser interferometer, Renisahw ML-10 Gold Edition
  - Encoder calibration

At vacuum:

- Vacuum level, background, RGA
- Resolution, accuracy, repeatability, backlash, … with the calibrated encoder.
- Duty cycle, temperature rise and steady state
- Bake out
  - Repeat test by means the Encoder